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Study of patellar kinematics after reconstruction of the medial patellofemoral ligament

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ABSTRACT

Background: Medial patellofemoral ligament reconstruction is currently the technique of choice for the treatment of patellar instability. But what should be the most appropriate graft tension for optimal restoration of patellofemoral kinematics?

Methods: Six freshly frozen cadaveric knees were studied, the three bone segments were respectively equipped with opto-reflective markers. The acquisitions were made using the Motion Analysis System®. Six successive acquisitions were performed for each knee under different levels of graft tension.

Findings: With an intact medial patellofemoral ligament, the medial patellar tilt increased up to a mean value of 2.02° (SD 3.1), the medial patellar translation gradually increased up to a mean value of 3.3 mm (SD 2.25) with a slight lateral rotation over the first 30° of knee flexion with a maximum mean value of 1.22° (SD 0.8) at 20° of knee flexion.

Reconstruction of the medial patellofemoral ligament was performed using different levels of tension applied to the graft. Only 10 N of graft tension could restore normal patellar tilt, lateral shift and rotation, with results approximating those measured on healthy knee.

Interpretation: This study confirms the role of the medial patellofemoral ligament in providing adequate patellar stability during the first 30° of knee flexion. According to our findings, a 10 N tension applied to the graft appears sufficient to ensure proper control of patellar tracking whereas 20, 30 and 40 N of tension are excessive tension values inducing a major overcorrection in all studied parameters.

1. Introduction

Medial patellofemoral ligament (MPFL) reconstruction has become popular in the treatment of patellar instability. Such reconstruction is based on biomechanical postulates described in the literature: the MPFL is put under a maximum tension of 30 N at 30° of knee flexion (Amis et al., 2003). Various specific complications have been reported after surgical reconstruction of the MPFL (Elias and Cosgarea, 2006; Thaunat and Erasmus, 2009). Among these complications, postoperative stiffness is the most frequent (Thaunat and Erasmus, 2009). It may be attributed to malpositioning of the tunnels with poor recovery of graft isometry and graft shortening during knee flexion, but may also be observed in case of graft overtensioning. Some studies have reported detrimental effects of graft overtensioning on patellar tracking (Elias and Cosgarea, 2006). But what should be the most appropriate graft tension during MPFL reconstruction to achieve optimal restoration of patellofemoral kinematics? Various studies have already been conducted, they use different protocols, some assess patellofemoral contact pressures before and after MPFL reconstruction (Beck et al., 2007; Melegari et al., 2008) while others compare graft tension before and after MPFL reconstruction (Ostermeier et al., 2007a, b; Sandmeier et al., 2000). However the influence of MPFL tension on the three-dimensional behaviour of the patella during the knee flexion cycle has never been dynamically studied.

The purpose of our cadaveric study was to determine through an optoelectronic analysis protocol already validated in the literature (Philippot et al., 2010) the most appropriate graft tension applied during MPFL reconstruction to approximate the original physiological conditions.

2. Methods

2.1. In vitro kinematic analysis protocol

The process for in vitro kinematic analysis of the knee is described in more detail in Philippot et al. (2010). Following is a brief description.

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Six freshly frozen anatomic specimens were studied. They were taken from subjects of mean age 69.6 years (SD 6.2). Each piece included the whole leg bone but also complete tendon-muscle and capsular ligaments structures. Specimens with a history of trauma and those with degenerative signs were excluded. A thawing phase was performed in ambient air over a period of 24 hours.

The assembly set up for this study included a cadaveric whole Femur/Tibia/Patella. The femur was fixed horizontally on a rigid support by two trans-osseous screws which prevented any movement at the bone segment. The knee joint was free and unconstrained since the assembly allowed to achieve a full range of motion at this joint from hyperextension to maximum flexion. The quadriceps tendon was identified and prepared by tacking stitch then a load of 10 N was applied collinear with the anatomical axis of the femur. The three bone segments were respectively equipped with opto-reflective markers (Fig. 1) in order to assess the relative movements of the 3 elements against each other and within six degrees of freedom.

2.2. Reference landmarks and data acquisition

The Motion Analysis System® was used for data acquisition. Biomechanical landmarks used for each bone segment were determined according to the criteria of the JCS (Joint coordinate system) defined by Grood and Suntay (1983). Each measured angle was defined relative to the Femur (Fig. 2).

Based on data from the literature and for easier interpretation and comparison with other data published in the literature, all these parameters were set to the “0” position in full extension (that is to say at 0° of knee flexion). The three-dimensional analysis of patella joint kinematics was performed on the six degrees of freedom of the patella with our optoelectronic analysis system. It was previously shown that the MPFL has a statistically significant action in only three of the six spatial parameters (Philippot et al., 2010). Thus we studied the results for only these three parameters: Patellar tilt (patellar rotation around the Yp axis), Patellar shift (patellar translation along the Zp axis), Patellar rotation (patellar rotation around the Xp axis).

2.3. Data collection

For each knee, the same movement was performed during acquisitions; its starting point was the reference position that is full extension of the joint, and up to 90° of knee flexion. This movement was not automated and done manually without constraint over a period of 1 second and 1 second to return to the reference position. Each acquisition consisted of five complete cycles of flexion and extension of the knee joint.

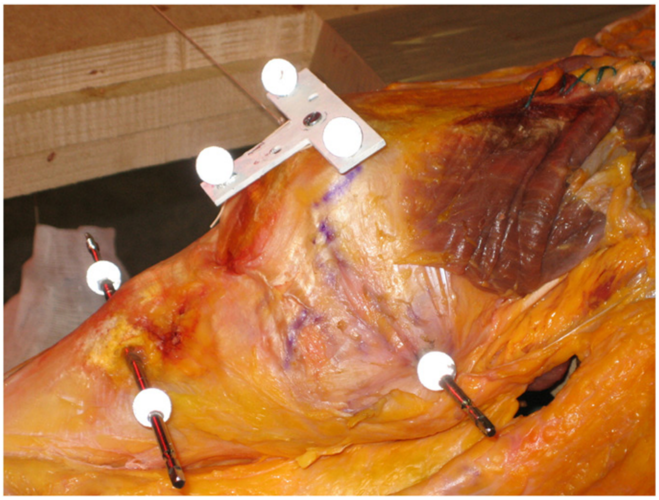

Fig. 1. The three bone segments were respectively equipped with opto-reflective markers.

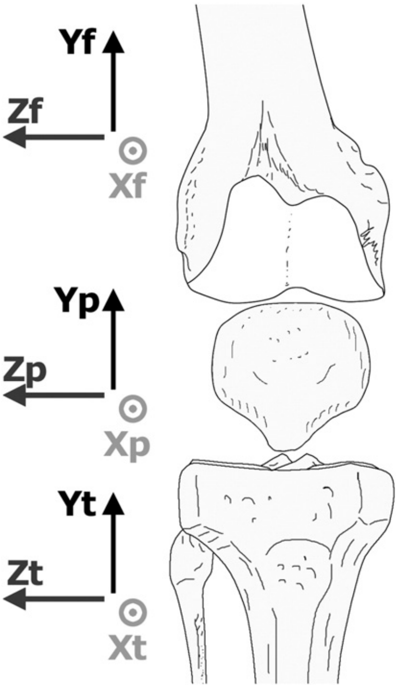

Fig. 2. Biomechanical landmarks used for each bone segment were determined according to the criteria of the JCS (Joint coordinate system). Each measured angle was defined relative to the femur.

Six successive acquisitions were made for each knee:

1. Analysis of patellar kinematics in the healthy knee.
2. Identification and transection of the MPFL at its patellar attachment.
3. MPFL ligament reconstruction with graft tensioned under 10 N.
4. MPFL ligament reconstruction with graft tensioned under 20 N.
5. MPFL ligament reconstruction with graft tensioned under 30 N.
6. MPFL ligament reconstruction with graft tensioned under 40 N.

2.4. MPFL ligament reconstruction technique

A midline skin incision was made and the knee was released of its cutaneous and subcutaneous plan. The semi tendinosis was harvested by stripping then the graft was prepared. The tendon was then released from all its muscle fibre adhesions, the obtained graft was 20–25 cm in length and was folded into 2 bundles. A non-absorbable traction suture was positioned to obtain two bundles of the same length (Fig. 3).

Graft harvest was undertaken at the beginning of the procedure prior to the six optoelectronic acquisitions.

The medial femoral epicondyle and adductor tubercle were palpated for accurate positioning of the femoral tunnel using the criteria previously defined by Philippot et al. (2009), that is to say 10 mm distal from the adductor tubercle and 10 mm posterior to the medial femoral epicondyle. A pin was inserted at the defined point; its path was oriented forward and proximally. A 6 mm diameter drill was used to make a tunnel of 30 mm in length. The tunnel was intentionally longer than the insertion length of the graft in order to adjust the tension by sliding it into the tunnel. The traction suture was passed into the pin and the graft pulled inside the tunnel.

Patellar superficial retinaculum was incised longitudinally and then raised as a flap. The medial border of the patella was sharpened